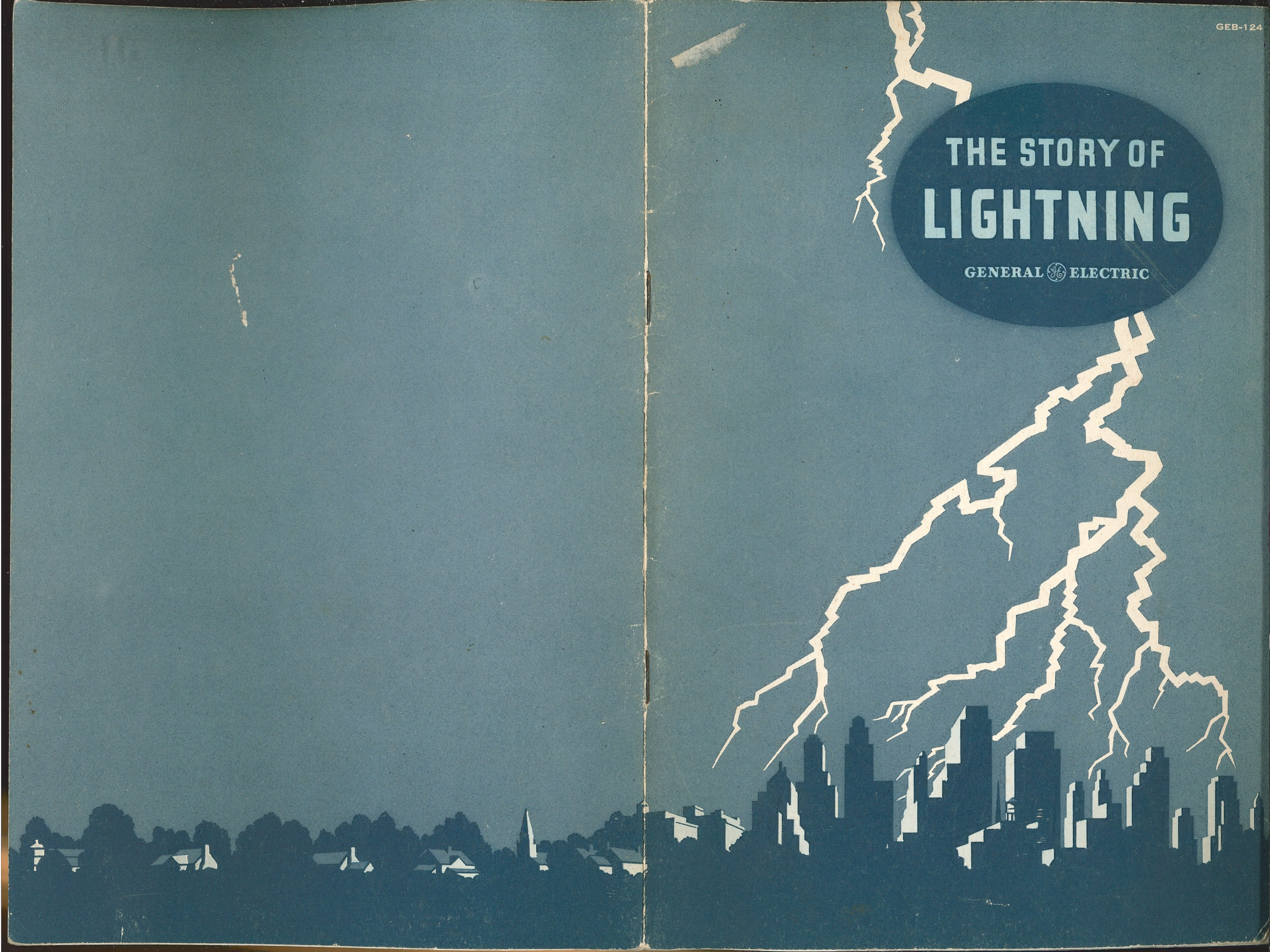


THE STORY OF LIGHTNING

GENERAL  ELECTRIC



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THE STORY OF LIGHTNING

IN THE age in which we live Nature's secrets are no longer her own. Man, ever seeking more knowledge, has probed into her mysteries to protect himself and to make his civilization greater.

Even Nature's great secret, lightning, has fallen before this thirst for knowledge. Under the curiosity of Franklin and the probing, scientific mind of Steinmetz, the "weapon of the gods" has been stripped of its age-old mystery. Today, under the direction of Dr. Karl B. McEachron, the men who call themselves lightning hunters are learning more and more about the jagged streak of fire that fills the stormy skies, are duplicating its feats with machines of their own making.

The history of lightning may not be completed in our lifetime, but already it is a story which holds a strange fascination.



A book, *Playing With Lightning*, telling the complete story of man's progress in solving the mysteries of lightning, has been written by Dr. Karl B. McEachron and K. G. Patrick and is published by Random House.

GENERAL  ELECTRIC

Dr. K. B. McEachron at work in the Pitts-
field Lightning Observatory.

THE STORY OF LIGHTNING

SCIENTIFIC STUDY BEGINS

On an August afternoon in 1920 Dr. Charles P. Steinmetz, General Electric's mathematical wizard, and his laboratory assistant had planned to leave Schenectady for the cool Steinmetz camp on the Mohawk River. But a swiftly gathering storm spoiled their plans and in all probability saved their lives.

For lightning struck the camp—struck, in fact, the table where Dr. Steinmetz usually worked. Trees were splintered, two-by-fours were smashed, wires were fused, lights were burned out, and a mirror was broken into fragments.

So fast does the modern world move, that already small incidents like this are forgotten and men like Steinmetz are remembered only for their far-reaching achievements, which acquire even greater luster as time passes.

Yet no story of lightning could begin without at least a glance backward at this incident. For it was here that the first serious study of lightning was begun. Lightning had struck on Steinmetz's own property, where no one could tamper with the evidence, and the scientist went over the ground as would Sherlock Holmes on the scene of a celebrated crime.

The bolt had first struck a tree a foot away from the camp window. Then it had broken the window and leaped inside. There it had splintered the Steinmetz work table, jumped to the far side of the camp, and shattered a mirror.

*The Steinmetz camp
on the Mohawk where
scientific study of
lightning began*



Steinmetz had the pieces of the broken mirror collected and fitted together between two sheets of glass, so that the pattern struck off by the lightning charge could be studied. This pattern constituted perhaps the first "portrait" ever preserved of lightning's effect. It was one of the first scientific approaches to the study of lightning.

FEAR AND SUPERSTITION

Lightning, striking with a roar and a blinding flash, uprooting trees and fusing metals, bringing destruction and even death in its wake, has enjoyed a commanding and fearsome stature in the sight of man since the beginning of time.

Lightning's history is, in reality, the history of man's attitude toward lightning. This began long ago with primitive man, who crouched in his cave and watched the flashes with a mixture of fascination and fear.

The fear has remained, and so has the fascination. Down through the centuries lightning has run neck and neck with ghosts and spirits as the inspiration of storytellers. Even today stories of the strange pranks of lightning receive columns of space in newspapers.

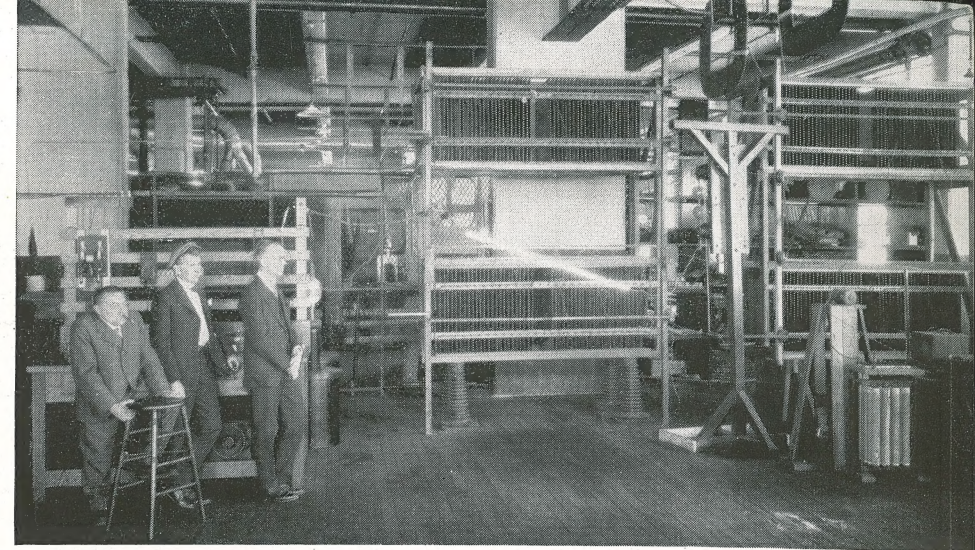
There is, for instance, the story of the lightning bolt which ignited a building and then struck a fire alarm box nearby, bringing firemen to the scene.

Then, too, there is the story of the seven-year-old boy who took shelter under a tree during a lightning storm and sat in his cart while waiting for the storm to clear. Lightning struck the tree, side-flashed, and removed three sides from the boy's cart—but left the boy unharmed.

Benjamin Franklin performed perhaps the best-known experiment in electrical history when he disproved the superstitions which had been built up around lightning. It is doubtful, though, if he knew



On June 21, 1936, lightning did this to the home of Julius Saxton, White Plains, N. Y.



The first artificial-lightning generator being demonstrated in the laboratory of Dr. Charles P. Steinmetz

just how much personal risk he was taking by flying a kite up into the clouds as he did.

Franklin made two important contributions to the study of lightning. He discovered that lightning is electricity, and he developed a system of lightning rods for the protection of buildings.

Franklin, however, had been impelled to solve the mystery of lightning by his natural curiosity. With Steinmetz in 1920 it was a different matter.

ARTIFICIAL LIGHTNING—A REALITY

Steinmetz's interest in lightning had grown gradually, induced by the problems of transmitting and distributing electric current. The answer to these problems, Steinmetz knew, was in better protective devices against lightning. Protective devices had been in use since Franklin's day, but they were not well understood and could be improved. Soon after the incident at the camp on the Mohawk, Steinmetz decided that before more efficient equipment could be built it would be necessary to study lightning itself.

It was a decision that was easy to make but very difficult to accomplish. Up to this time it had been impossible to obtain precise information on what happened when lightning struck; no one could be sure of when or where it would strike.

But why couldn't man make his own lightning and control it?

Steinmetz thought it could be done, and in 1921 he began building the first artificial-lightning generator.

The big machine, when finished, could create lightning which was about one five-hundredth as powerful as natural lightning, producing a potential of 120,000 volts, and 1,000,000 horsepower.

This first crude generator, demonstrated in the winter of 1922, was a queer sight to the skeptical eyes of observers. There were stacks of large glass plates, coated with metal foil, connected by wires to a power source, and wired to a discharge path. Electricity accumulated in the plates just as it accumulates in a thundercloud. When the plates could hold no more, electricity in the form of artificial lightning leaped across the discharge path. The discharge was accompanied by a loud crash. This was artificial thunder.

For the first time now, scientists and engineers had a form of lightning, very like natural lightning, under control, and they knew when and where it was going to strike. There were no more skeptical smiles from observers.

In 1923 a second generator was built. It was larger and much more powerful than the first, but Dr. Steinmetz never had the opportunity to use it. Death claimed him before it was completed.

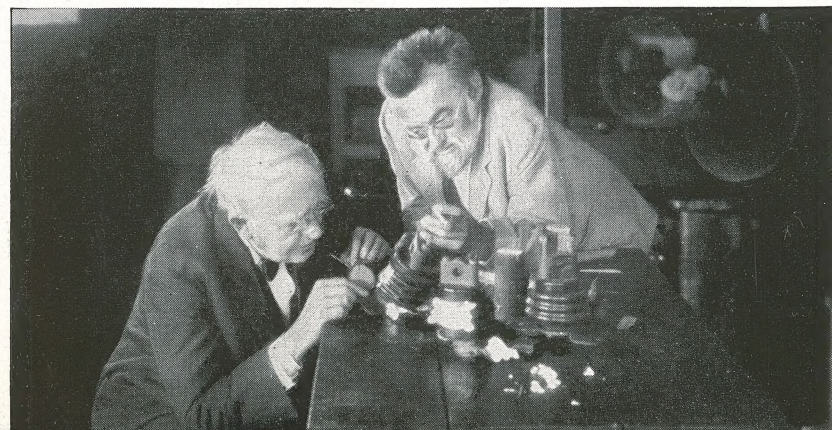
These things are history. Steinmetz had literally set a trap for lightning and caught it. After Steinmetz's death, Frank W. Peek, Jr. took up the work in the General Electric Company's Pittsfield Laboratory, which has since become the headquarters of most lightning hunters. Lightning study became a fertile field where many labored, always with the aim of conserving life and property.

THE WHY AND WHEREFORE

When the use of electricity in the home was still rare, a break in electrical service was no great hardship. But today, if lightning damages transmission lines, the home and factory are reduced to utter helplessness.

Transmission lines—those connected systems of wires which conduct electric current from one point to another—are intricate

Edison and Steinmetz examine an insulator that has been struck by artificial lightning



things. They must be insulated from the earth, for the earth itself is a conductor of electricity and the current carried by the wires cannot be allowed to go to the ground and escape. For this reason wires are strung up on towers and are insulated from them by glass or porcelain insulators whose size and length depend upon the voltage which the wires must carry. The higher the voltage, the greater the electrical strength required by the insulators which separate the wire from its supporting tower.

The great transmission systems which span the country, supplying electricity for domestic and industrial purposes, operate at very high voltages. The one which connects Boulder Dam with the city of Los Angeles, for instance, carries 287,000 volts. The insulators separating the cables from the towers on this line are 10 feet in length. The wires are separated from each other by at least 24 feet.

Thus as much air as possible is put between the wires themselves and between the wires and the ground. For, though air is normally a nonconductor of electricity, it breaks down when a sufficiently high voltage is applied. And it is lightning striking transmission lines which accounts for many sudden surges in voltage.

When lightning strikes a wire, voltage rises progressively along the line until it reaches an insulator. There the lightning may jump across to the tower and go to ground. If it does, the ordinary current will follow and go to ground also, interrupting service. This is called a flashover. In some sections of the United States there have been as many as 40 flashovers a year for every hundred miles of transmission line.

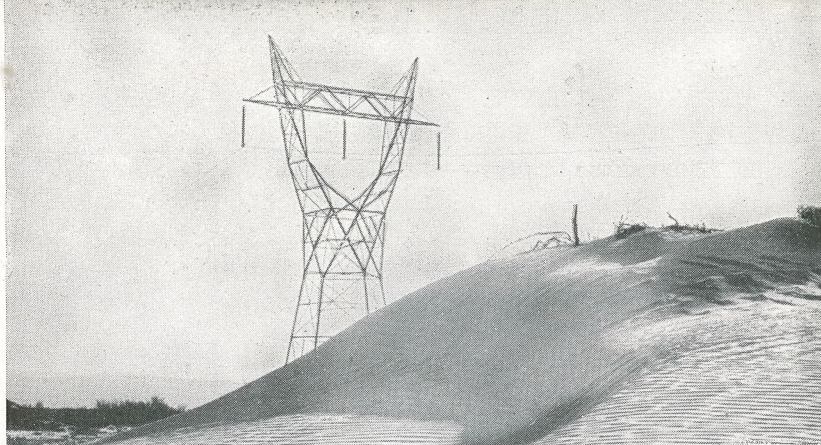
In the event that considerable excess voltage continues on the line without having sufficient magnitude to cause a flashover, it may damage apparatus in the power plant.

In either event, a whole city's power may fail, with results which may be minor, such as interrupted bridge games, or occasionally serious, as when a delicate hospital operation is halted.

Engineers and lightning hunters have developed several means of protecting transmission lines from lightning. Most of these either disconnect the power line from the power station automatically immediately after lightning strikes, allowing the lightning to flow to ground, or else intercept the light-

Lightning presents danger to power lines





A steel transmission tower in the high-voltage line from Boulder Dam to Los Angeles

ning and offer it a quick way to ground before it can reach the transmission line.

But even the best of these defenses are not infallible, and many a power-plant engineer, observing the destruction caused to transmission lines and power apparatus by an electrical storm, has wistfully wished he might rely on that popular conviction that lightning strikes but once in the same place.

Unfortunately the old adage is untrue. For there is nothing in nature that will prevent lightning from striking ten, one hundred, or even a thousand times in the same spot—though frequently once is enough. The fact that lightning has struck a spot once is warning that it may strike again, for it means that circumstances at the spot struck may offer a special attraction to lightning.

Lightning protection for electrical equipment is more important today than ever before—not because lightning has changed, but because man has dared to harness electricity to turn the wheels of industry; he has a longer frontier to defend. And his first step in any defense lies in learning of what the danger consists.

The work of Franklin and of Steinmetz—work separated by nearly two centuries—gave man his first inkling of what he was fighting.

THE 10,000,000-VOLT GENERATOR

After the death of Steinmetz, F. W. Peek, Jr. built a new impulse generator in General Electric's High-voltage Engineering Laboratory at Pittsfield—a "big gun" of 3,600,000 volts.

But progress in lightning research was so rapid that Peek's giant gun was soon regarded as pioneer apparatus. Old methods were discarded. In 1925 Marx developed a new type of impulse-generator

circuit. This solved many of the problems which had faced the lightning hunters. In effect it put man-made lightning in a suitcase and freed it from the laboratory enclosure.

With the development of the portable units made possible by the Marx circuit, engineers could go into the countryside, create their own lightning storms, and measure results on typical transmission lines.

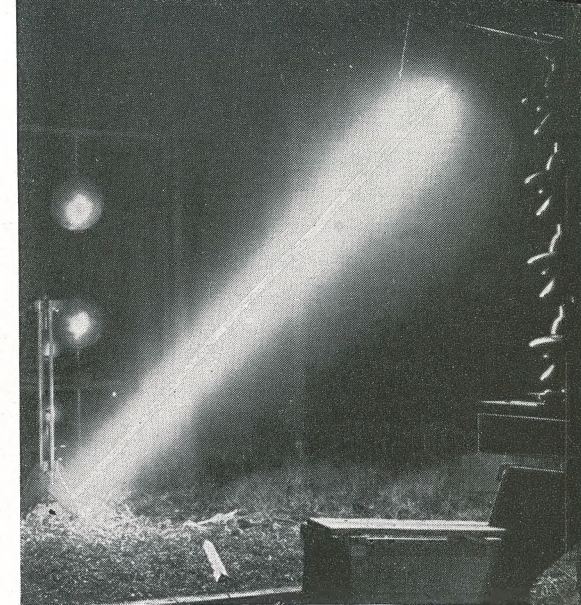
The climax in the development of man-made lightning came with the building in Pittsfield of an impulse generator capable of producing 10,000,000 volts of artificial lightning. The big machine's power output, in a discharge lasting ten millionths of a second, was more than 13 times the total electric power developed at Niagara Falls!

In 1933, with the untimely death of Mr. Peek, Dr. Karl B. McEachron became director of General Electric's High-voltage Engineering Laboratory in Pittsfield and assumed the leadership of a group of lightning hunters whose avowed purpose was to determine the nature of lightning itself. Since leaving his instructorship at Purdue University, Dr. McEachron had worked for 11 years in charge of a group of engineers developing lightning arresters for the protection of power and distribution transformers. Under his direction the work of lightning research went forward unceasingly.

WORLD'S FAIR THUNDERBOLTS

A generator similar to the 10,000,000-volt machine built in Pittsfield—but with output increased nearly 50 per cent—was built for display at the New York World's Fair in 1939. This monster with its crashing voice and fiery tongue thrilled millions of visitors at Flushing Meadows until the fall of 1940. With its knobs and stacks in black and chromium, it looked like a bizarre scientific creation brought to earth from Mars.

The appearance of the demonstration hall in which the big generator performed, with the lights lowered, the red signal lamps glowing, and with the tall, forbidding stacks of black and chromium glittering



The 1,000,000-volt portable lightning generator at work on location in 1931

evilly, was enough in itself to quicken any watcher's pulse. And the odor of ozone which pervaded the atmosphere as a result of past demonstrations served to increase this feeling of tension and uneasiness. During the 15 seconds required for the big lightning generator to reach its full charge, the ominous hum of the apparatus put nerves on edge.

The stacks of capacitors were discharged just as are nature's clouds, each discharge making a bright arc 30 feet in length from the foremost point of one generator to a similar point on the other.

In one of the demonstrations, a hard maple post was split by the artificial lightning. There was always a fine line in each piece of the split wood after this demonstration had been completed, indicating the path of the discharge. The wood along this path had been turned into gas, and it was the expansion of this gas which caused the wood to split.

With the development of the 10,000,000-volt producer of man-made lightning it became possible to study the effect on electric apparatus of artificial lightning which was very close to natural lightning. Today, although the outdoors is still the laboratory of the lightning hunter, much valuable information is being obtained in working with the more controlled lightning produced under the laboratory roof.

MEASURING DEVICES

The perfection of the great artificial-lightning producer meant that the two difficulties encountered in the study of natural lightning had been overcome. With the new apparatus lightning could be studied while discharging, and it could be measured.

Measurement is the theme song of the lightning hunter, and some queer looking yardsticks are employed in the process of measuring Nature's destructive outlaw.

Perhaps the most familiar measuring device is the sphere gap. Used as background in many movie thrillers, it consists of two large

metal spheres, properly supported, and separated by an air gap across which an electric arc is made to jump. The distance which the arc jumps is the measurement of its potential, or voltage.

The spheres of the spark gap constitute the two electrodes of the gap, just as the cloud and

the earth are the electrodes for a natural lightning flash to the ground.

The shape of these electrodes has much to do with the voltage value necessary to send lightning across the gap. If one electrode is sharp as a needle point and the other electrode flat, then the voltage required is reduced. This is why a tree or a steel tower usually acts as a guiding point for discharges that might otherwise have taken place over a considerable area. Sphere-shaped electrodes act to equalize the stress, avoiding concentration, and, with these, a very high voltage is necessary to send lightning across the gap.

THE LIGHTNING ROD

The lightning rod acts in a small way as a needle point electrode, and lightning strokes nearby are guided to it and safely grounded.

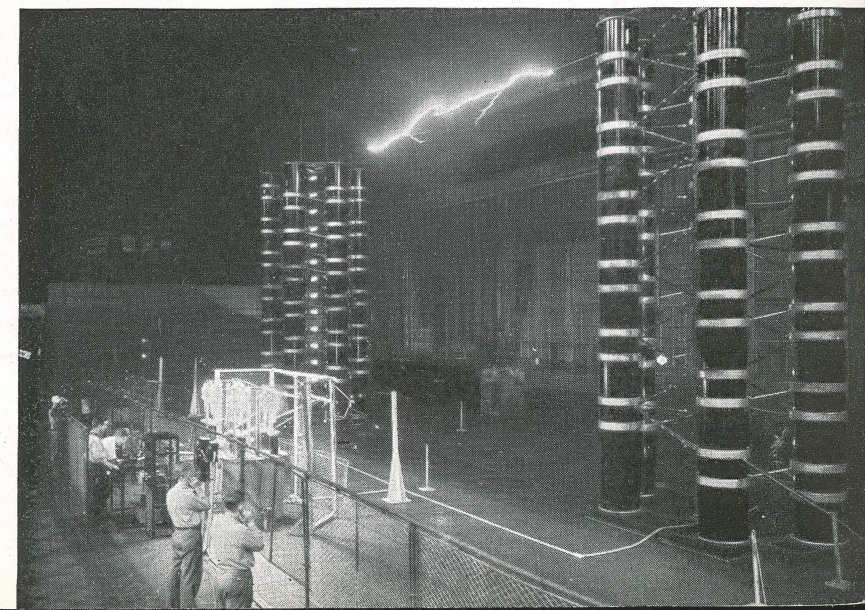
The lightning rod is probably one of the oldest electric appliances known to man. It was invented and placed in service long before electric current was generated and transmitted for human use. For a century ago lightning was not exactly welcome, even if it was free electricity, and the lightning rod was meant to by-pass it as thoroughly and speedily as possible.

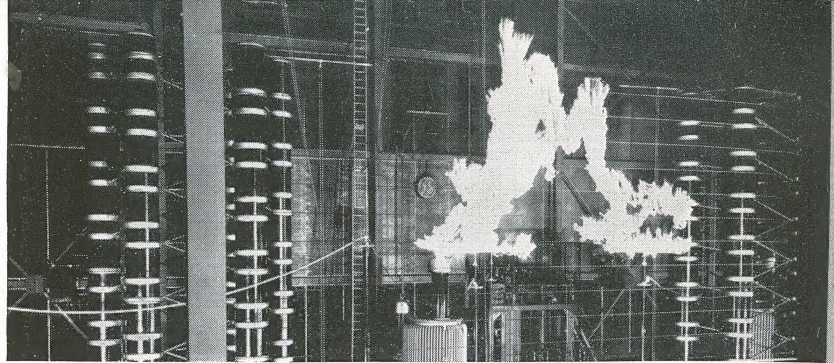
Lightning rods today are a very serious business. When properly installed, they afford a high degree of protection and often save many times their cost in fire prevention alone.

This is especially true in the open country, since lightning is more likely to strike buildings there than in the city. Exposure in the

A test assembly of the 10,000,000-volt artificial-lightning generator built for the New York World's Fair, 1939

Dr. K. B. McEachron, head of General Electric's High-voltage Engineering Laboratory, inspects a photograph of a lightning stroke





A million-volt, three-phase arc as seen from the gallery of Steinmetz Hall at the New York World's Fair, 1939

country is considerably greater, and the absence of high buildings means that the stroke will not be diverted.

Nearly 2000 people are killed or injured by lightning in the United States each year. Nine-tenths of these casualties occur in rural areas!

Not all lightning rods are installed in rural districts, however. Some are used in the cities to protect fine trees or skyscrapers.

One such example is the General Electric Building in New York City, which rises more than 500 feet in the air. The building, when new, was struck and damaged on three different occasions. Investigation disclosed that steelwork had not been carried to the upper extremity of the tower, and that the building was topped by 50 feet of brick with nongrounded reinforcing members.

When struck, blocks of this brick were thrown in all directions, endangering the lives of people below. The danger was eliminated by equipping the building with a lightning rod system which would conduct strokes harmlessly to the ground through the steel framework of the building.

TRAPPING NATURE'S OUTLAW

When ways of dissecting *artificial* lightning had been found, the lightning hunters turned once more to the study of *natural* lightning.

Here they faced the problem of catching Nature's outlaw "on the fly," and it was only natural that they should resort to photography.

In this work the ordinary camera was of little use, for it failed to indicate how long the discharge lasted, whether more than one discharge occurred, or whether the stroke was initiated in the cloud or on the ground. Investigation proved that the problem could be solved with a special camera employing a rapidly moving film, thus supplying the time dimension needed. The film velocity of this camera is approximately a mile a minute!

Another problem, which arose after ways of catching lightning had been found, was to locate a place which lightning visited many times during the year. Queerly enough the "portrait studio" needed was found right in New York, high up in the tower of the Empire State Building. This building, sticking high above the others in New York, acts as a needle electrode, and nearly all discharges in the nearby area are guided to its tower.

Equipment to register lightning strokes was installed in the building and photographic equipment was located at 500 Fifth Avenue, eight blocks away. From there an excellent view is obtained of the Empire State tower.

The investigation from this point is still going on, and the lightning hunters who operate the equipment are part electrical engineer, part photographer, and part night watchman. Nearly all their work is done at night. Tips on approaching storms come to them from New Jersey, from the Public Service Electric & Gas Company or from the weather bureau of the Newark Airport.

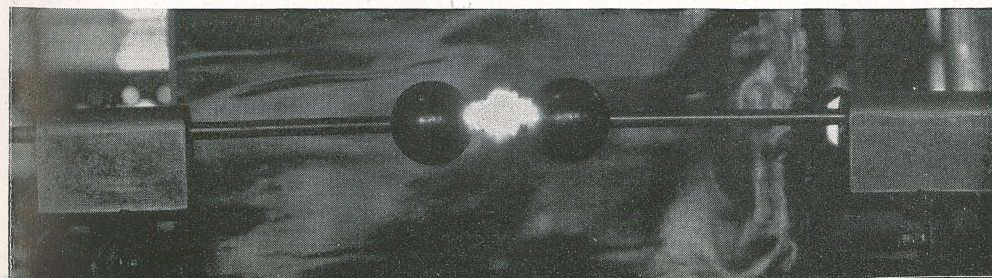
The lightning hunter is usually in his hotel room when he gets the tip. He leaps into his clothes, finds a taxicab, and proceeds to the Empire State Building. The night elevator man takes him up 102 floors, and he climbs the last two floors to the tower on foot. On location, he closes the switches, waits for the apparatus to heat up, and then dashes to 500 Fifth Avenue, where the elevator takes him up 50 or 60 stories to the camera location.

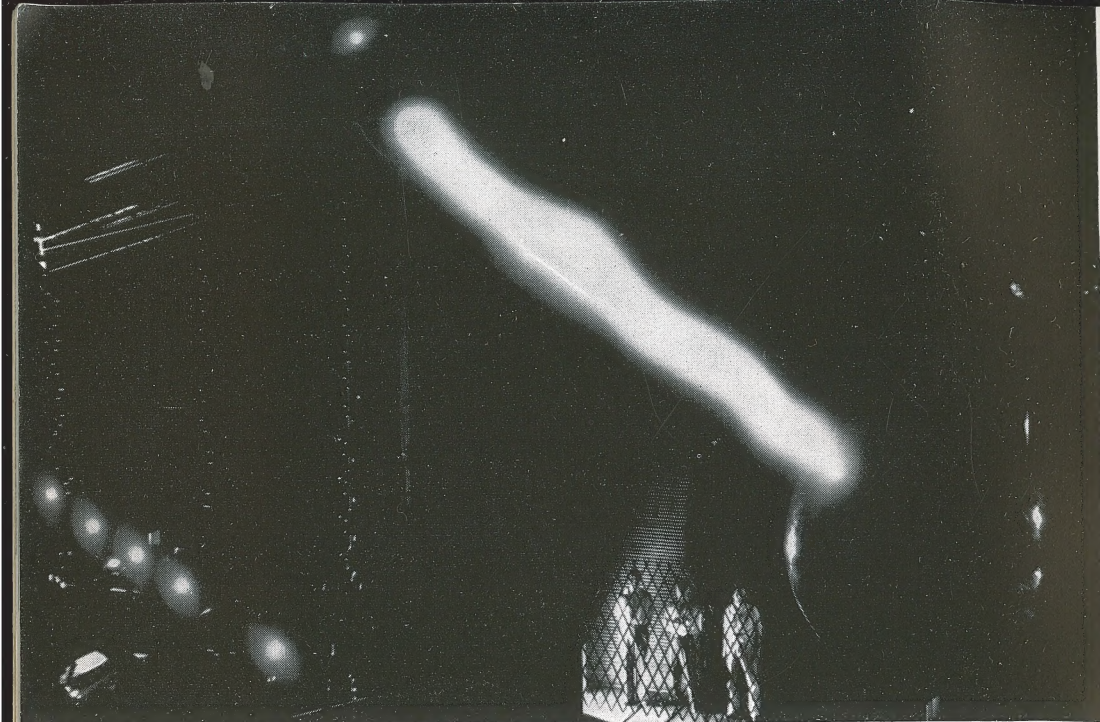
Many times his trip proves to be a false alarm and the storm does not reach the Empire State Building. There is nothing for the lightning hunter to do then but turn off his equipment and go home to await the next call.

If the storm turns up as predicted, though, the lightning hunter is set for the night. Both of his hands are kept busy handling equipment. His eyes must never leave the sky above the Empire State tower. He takes notes by speaking into a microphone attached to his lapel and connected to a dictaphone.

But the Empire State Building is not the only lightning observation post. There is another at Pittsfield, Massachusetts—a veritable crow's nest in the Berkshires. This was set up to study the random bolts that roam the heavens in open country.

Measuring high-voltage electricity with a sphere gap





A 5,000,000-volt artificial lightning discharge in General Electric's High-voltage Engineering Laboratory, photographed with a quartz lens

The Pittsfield Observatory, built almost entirely of steel and glass, is erected on the roof of one of the largest factory buildings in Pittsfield. It is round, and divided into three sections like a layer cake. The interior is painted black to prevent reflection. In searching for lightning, the observer stands on a platform, surrounded by black curtains, and views the heavens through a periscope which can be turned to cover the entire sky.

In the lower "layer" of the Observatory is the multiple-lens camera with its 12 lenses set in a circle to cover the entire horizon. To prevent rain from driving against the lenses, compressed air is forced across them, keeping the drops away.

THUNDER AND LIGHTNING

Not every lightning flash is accompanied by a clap of thunder, as is popularly supposed. Those that have little or no thunder may appear just as bright as the ordinary stroke, but their destructive force is smaller.

Thunder, as well as the physical rending and tearing created by a lightning stroke, is the result of the sudden expansion of air created by a fast-moving discharge. And since all flashes do not release

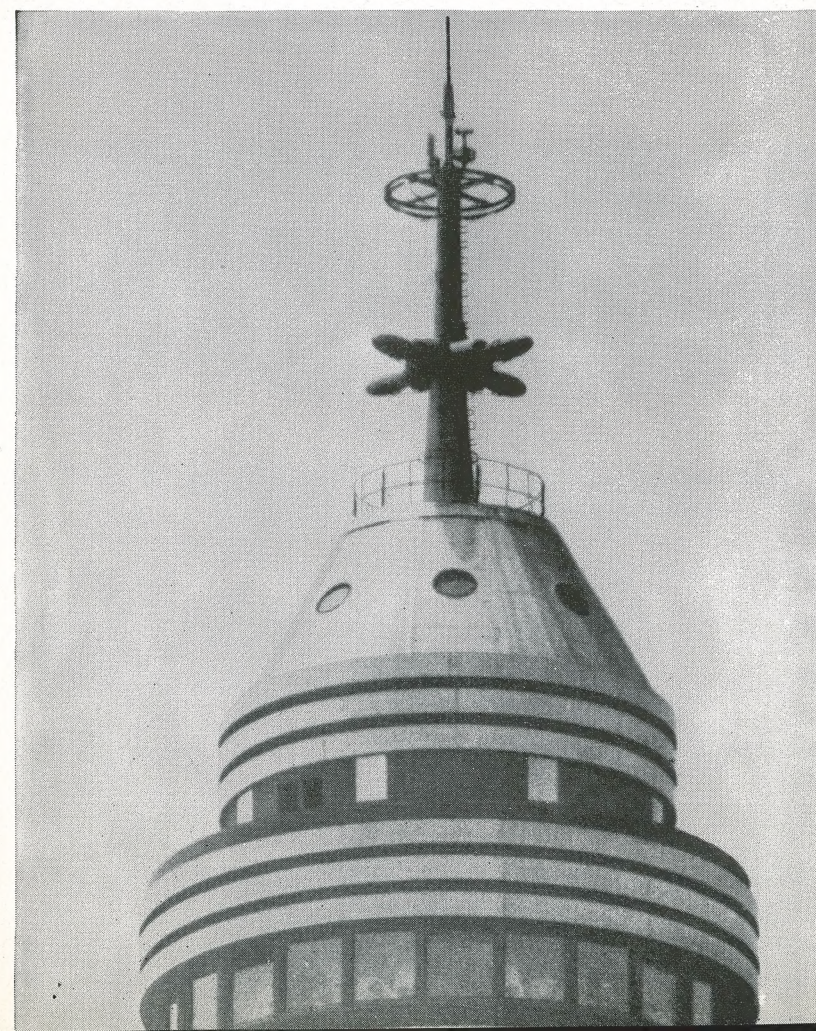
energy with the same speed, the expansion of air is sometimes too slow to create thunder.

Most thunder does not reach the ears as a single crack, because of the speed at which sound travels. For instance, one portion of a lightning discharge in the clouds may be six seconds away, while the portion of the stroke near the earth may be only one second away. Thus the sound reaches the ear as a continuous rumble.

The common expression, "The storm is coming back," is built on a fallacy. Thunderstorms, like boxers, seldom come back. It is quite common for several storms to follow each other through the same area, and one not in a good position to make observation gets the impression that the storm is returning.

During a thunderstorm a downward lightning stroke will distribute its negative charges from cloud to ground along its path. As these

Lightning equipment and television antenna atop the Empire State Building in New York



negative charges come closer and closer to the earth, the positive charges on the ground become more and more concentrated until, as the stroke comes within a few hundred feet of the ground, streamers may rise out of the earth to a considerable height. This effect was photographed recently on a New Jersey beach.

Thus, queer as it seems, an individual who gets in the way of a lightning stroke has probably been struck up from the ground rather than struck down from the sky.

It must not be forgotten, though, that in some ways lightning is a benefactor. For natural lightning produces, free of charge, about one hundred million tons of fixed nitrogen annually over the earth's surface. The air, composed roughly of four parts of nitrogen to one part of oxygen, is broken down by the passage of a lightning bolt, and fixed nitrogen is deposited in the soil with the rain.

When men manufacture fixed nitrogen, electric sparks 15 or 20 feet in length are employed. Nature's spark, lightning, may be thousands of feet in length, and if it were not for the extremely short duration of the lightning current it would produce immensely greater quantities of this essential agricultural chemical.

The General Electric Company's Lightning Observatory in Pittsfield



In some places where soil conditions are right, Nature leaves a record of the passage of lightning current in the form of a tree-like formation of fused sand called a fulgurite. These fulgurites, sometimes several feet in length and inches in diameter, are caused by the heat of the electric current passing through sand.

HIDE AND SEEK

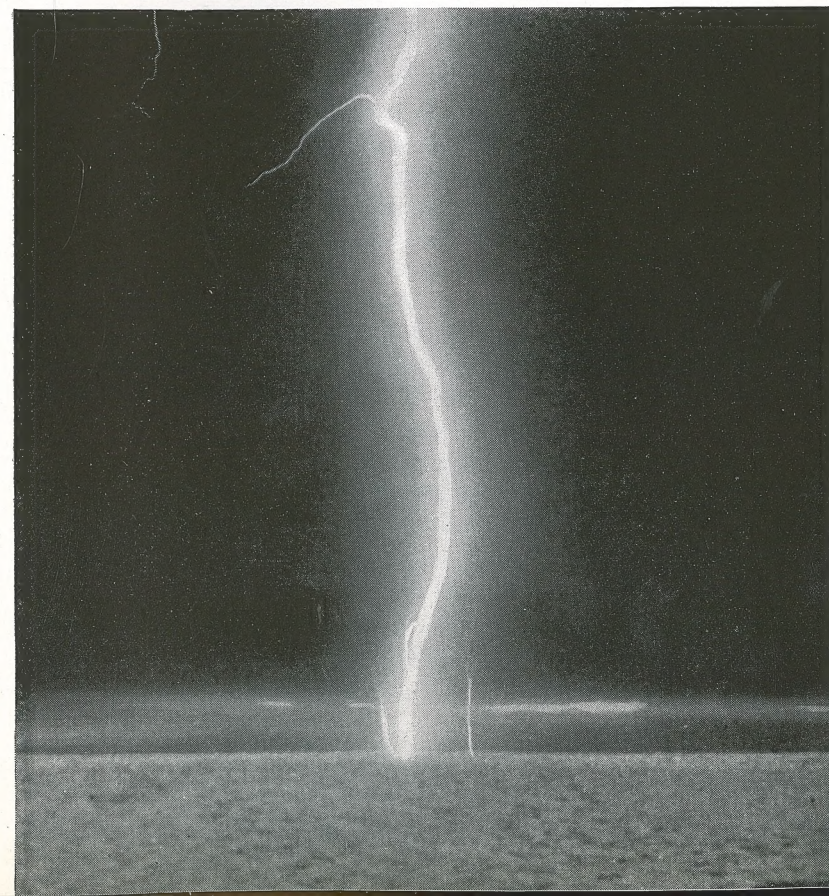
Though lightning is frequently accused of freak performances, it obeys natural laws, and most of its pranks can be traced to sound reasons.

As an example, lightning struck a large tree standing in front of a country home. It jumped from the tree to the house, making entrance just below the eaves. It passed through the wall and then through an iron bed without harming the man who was asleep in it. Then it passed through the floor to a stove in the kitchen just below.

Part of the discharge found its way to the ground by jumping across the kitchen from the stovepipe to the ground rod that had

A natural lightning discharge hits a sandy beach. Streamers can be seen rising out of the sand to meet the stroke

(Photographed from 100 feet by Robert Edwards. Courtesy Ewing Galloway, New York)





High-voltage fulgurite produced by artificial lightning in the laboratory

been installed by the telephone company. The barn back of the house was burned, presumably because the house was connected to the barn by a radio aerial and part of the lightning followed this path.

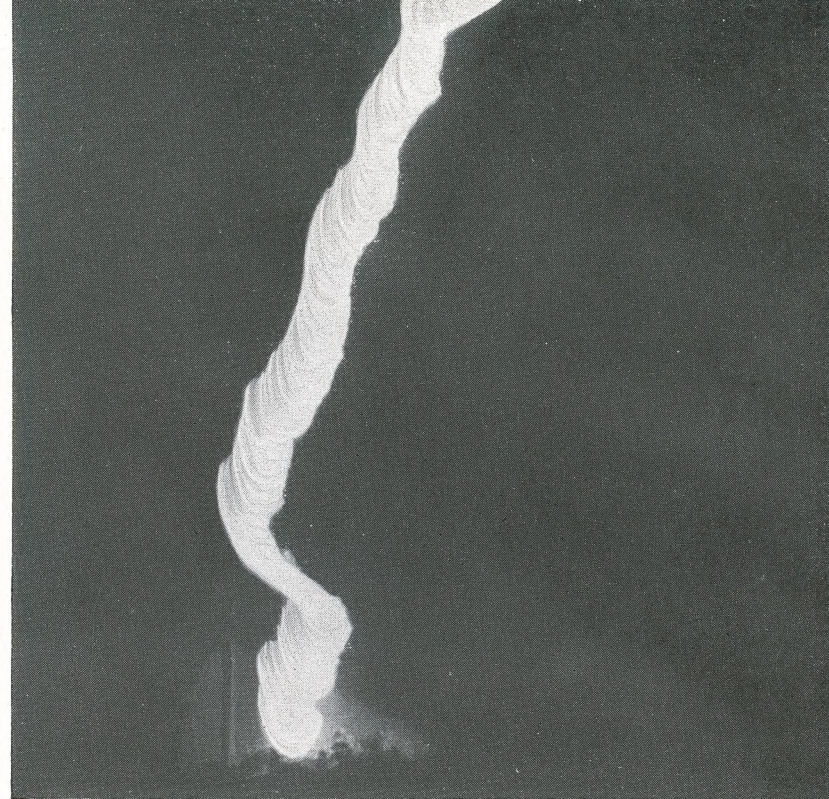
The man sleeping in a metal bed had much to be thankful for. Had the bed been made of wood, it is likely that the discharge would have passed through him on its way to the metal spring and then to the ground.

A very interesting, though unfortunate, case was one which resulted in the death of a young man at a Civilian Conservation Corps camp. The boy was killed during a storm while standing beside his bed looking out of the window. Lightning, in this case, struck a small

apple tree near the camp, arced a distance of 27 feet to the base of the building, went up through the floor into an iron bed, and into the right leg of the boy as he stood looking out the window.

It passed from the boy's chest to a plate which hung on the wall, then passed through a nail to the window screen. From the screen it jumped to the radio antenna under the eaves. It followed the antenna for a distance of 50 feet, jumped to an electric circuit inside the building two or three feet away, followed this circuit to the Captain's quarters 100 yards away, and there, at last, it achieved its first connection to the ground since leaving the earth under the building where the boy was killed.

One of the few advantages in weather that Little America enjoys over the more temperate regions is the absence of thunderstorms. A few years ago the Springfield, Mass., *Republican* destroyed even this advantage. On April 8, 1934, from the High-voltage Laboratory of the General Electric Company in Pittsfield, the newspaper sent by short-wave radio the crash of the General Electric Company's 10,000,000-volt artificial-lightning generator to Admiral Byrd's men on the Antarctic continent.



*(Supplied by Alice Gulda through Blue Hill Meteorological Observatory)
This photo of a continuing flash of lightning was taken from a boat on Lake Maggiore, Ascona, Switzerland*

The crash of this huge generator has also been recorded for future generations on the sound film buried in the Oglethorpe University Crypt of Knowledge. The crypt will not be opened for 6000 years.

Strange pictures of lightning have often been made. One of the strangest was taken in July, 1937 on Lake Maggiore in Ascona, Switzerland. At first glance it appears to show a sort of fiery tornado spiraling its way to earth. But the explanation is simple. It is a continuous lightning stroke and was taken from a boat which rocked and drifted so that the stroke was drawn out along a circular time axis.

UNFINISHED BUSINESS

The preceding pages have described briefly the battle being waged by the lightning hunters along a wide front, first to understand lightning, then to guard against it. And if these pages have served not only to satisfy some of the reader's curiosity about nature's outlaw, but also to warn him against carelessness and neglect where that outlaw is concerned, then they have accomplished part of their purpose.

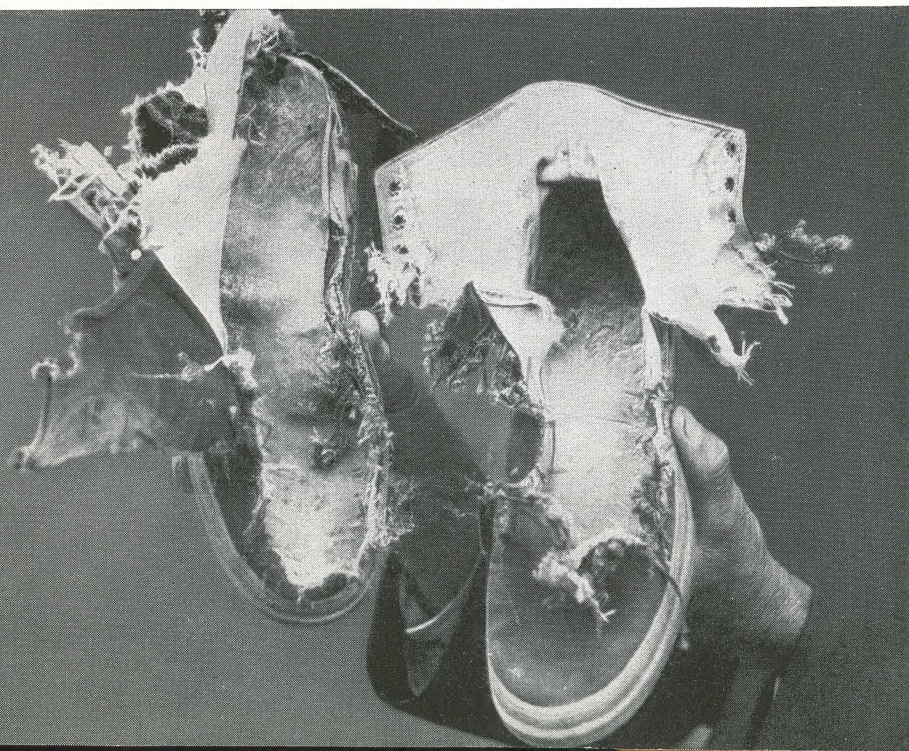
But this fascinating work of the lightning hunters has a still deeper meaning for us. For it is only part of a larger job—part of the unending search of scientists and engineers, working in the field of electricity, for ways to improve our electric service and make it more dependable.

Today we take for granted the perfection of that service. When we reach for a switch, we expect the electricity to be there, waiting, ready for the simple touch of a finger to set it doing our bidding. When a thunderstorm rolls up, we may expect the lights to blink a bit, but these days they seldom go out and stay out. And behind all this dependability, all this improvement, is the work of hundreds of engineers—men in laboratories, men in the engineering and service departments of the nation's power companies, men like the lightning hunters—constantly tracking down difficulties and correcting them and finding ways to avoid them in the future.

Most of the tools which these men have devised to improve electric service are less spectacular than the lightning traps and million-volt arcs of the lightning hunters. They are things like improved transformers, voltage regulators, circuit breakers and the relays which tell them when to operate. Things like the little cylinders of metal, only slightly larger than a cartridge fuse, which when fastened to transmission-line towers are magnetized by the lightning current flowing

Here's what happened to the shoes of one person who was struck by lightning. Oddly, the person wearing the shoes came through the experience unscathed except for badly cut feet

(International News Photo)



A switching station, electric lines, and an oil derrick form attractive targets for lightning here

through the tower, and which may be carried back to the laboratory and examined at leisure, giving a measure of the lightning current. Things like the automatic oscillograph installed in the powerhouse or the electric substation. When a disturbance caused by lightning comes galloping along the lines, this instrument swiftly goes into action, makes a permanent record, and from that record it is possible to tell where the lightning struck and to go out and locate the damage without the laborious job of tramping the transmission-line right-of-way and examining every tower.

Less than two generations have passed since Edison began supplying electric power from his Pearl Street station to a few feeble incandescent lamps in downtown New York City. Yet in that brief time—about half the period during which railroads have been operating—our whole vast electrical systems have developed. They did not spring into being fully grown. Every step, every new invention, every new service that electricity was made to perform was the outcome of study and trial and experiment on the part of men who pioneered just as the lightning hunters are pioneering today.

As a result of their labors, we pay approximately half as much for each kilowatt-hour of electricity we use in our homes today as we would have paid twenty years ago. An incandescent lamp costs less than

half as much, and gives more light. And the number of useful jobs that electricity has been made to do for us has grown steadily, year by year.

It is a continued story, this tale of how these searchers into the unknown are wresting new facts from the inexhaustible storehouse of nature and turning them into products and services for our benefit. New installments are turning up, day by day, in the records their instruments make, in the entries in their notebooks. So this *Story of Lightning* comes to a close, not because it is finished, but because the next chapters are even now being written by the lightning hunters.

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*"If you heard the thunder, the lightning did not strike you.
If you saw the lightning, it missed you; and if it did strike
you, you would not have known it."*

Karl B. McEachron

Natural lightning strokes photographed from the Pittsfield Lightning Observatory



A 5,000,000-volt stroke of artificial lightning strikes a model of the Empire State Building in the Pittsfield High-voltage Engineering Laboratory. The experiment was made to establish the protection offered by the building to surrounding structures

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